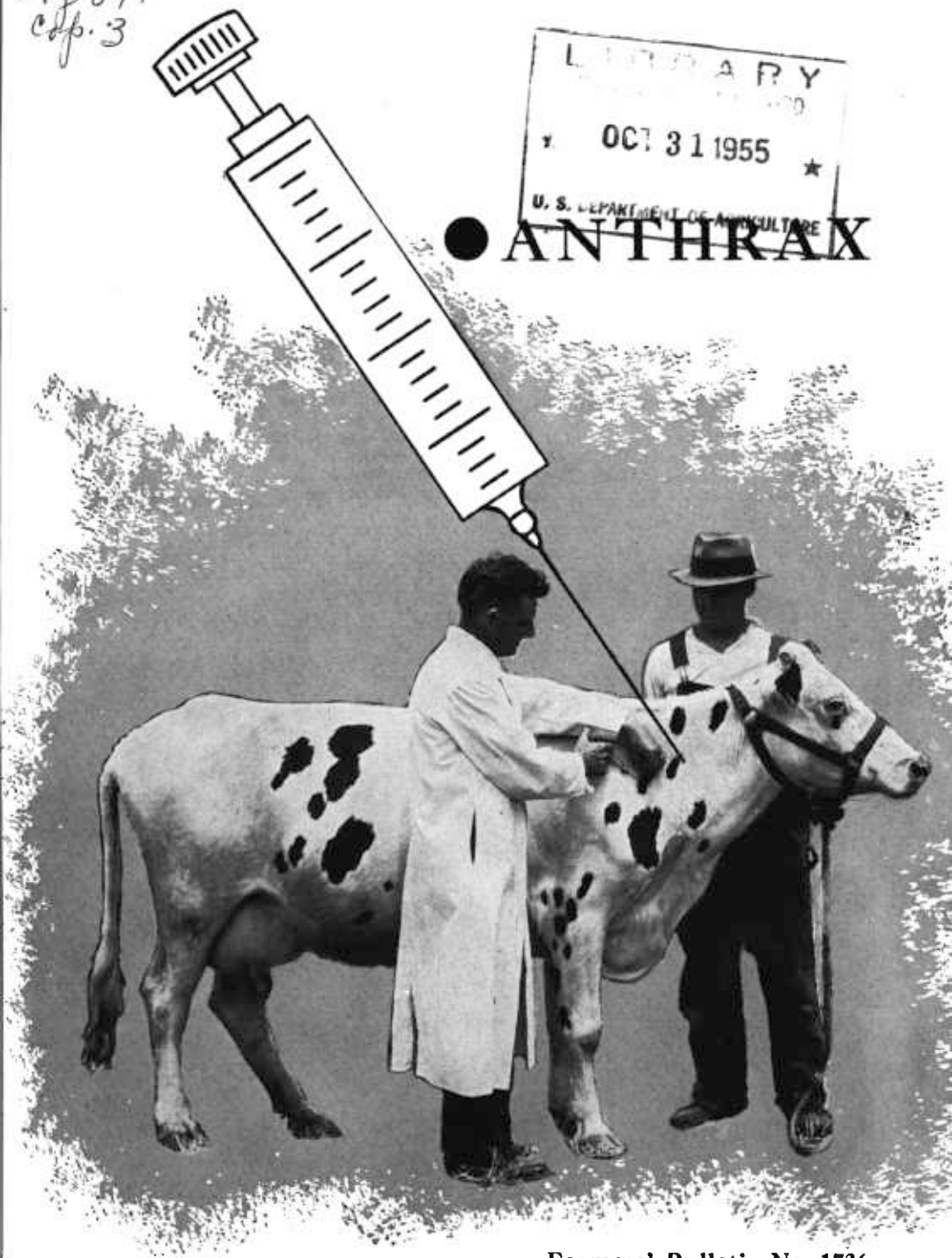
ANTHRAX



Farmers' Bulletin No. 1736
U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

Washington, D. C. Revised October 1955

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Washington 25, D. C. - Price 15 cents

ANTHRAX[1]

By C. D. STEIN, *veterinarian, Animal Disease and Parasite Research Branch, Agricultural Research Service*

ANTHRAX is an acute infectious disease of livestock and man. It usually presents a picture of acute blood poisoning. It strikes suddenly and kills quickly.

Anthrax is of great historic interest since it was the first of all infectious diseases of both man and the lower animals in which the causative agent was definitely demonstrated as a specific micro-organism, and it constituted the principal subject for study by the early investigators who laid the groundwork for the modern science of bacteriology. It was likewise one of the first infectious diseases against which a bacterial vaccine was found to be effective.

Anthrax causes annual losses of many thousands of dollars to the livestock industry and since it is infectious to man it is also a menace to public health. During the 8-year period from 1945 to 1952, 2,785 outbreaks were reported from 38 States with losses of 14,708 head of livestock having an estimated value of $1,387,500. During the same period the United States Public Health Service reported more than 400 cases of the disease in man.

History

Anthrax is one of the oldest and most destructive diseases of animals. Before the disease was known to be of an infectious nature, it took a heavy toll among human beings and caused great losses of livestock in many countries.

The early history of anthrax in livestock in the United States is somewhat obscure. The presumption is that it was implanted in the Rio Grande Valley and Mississippi Delta by explorers and primitive settlers from the Old World. In Louisiana, it has been traced back to the time of settlement by the French; widespread outbreaks in livestock and cases in man were recorded as early as 1835, and later in 1851 and 1884. The first cases in man recorded in the United States were in 1834 during outbreaks in livestock in Pennsylvania. Outbreaks in Mississippi are reported to have occurred as early as 1836, and later in 1865. Outbreaks were recorded in Texas in 1860 and in 1880; in New York in 1881; in Vermont and Massachusetts in 1887 and in California in 1888. Infected areas still exist in most of these States.

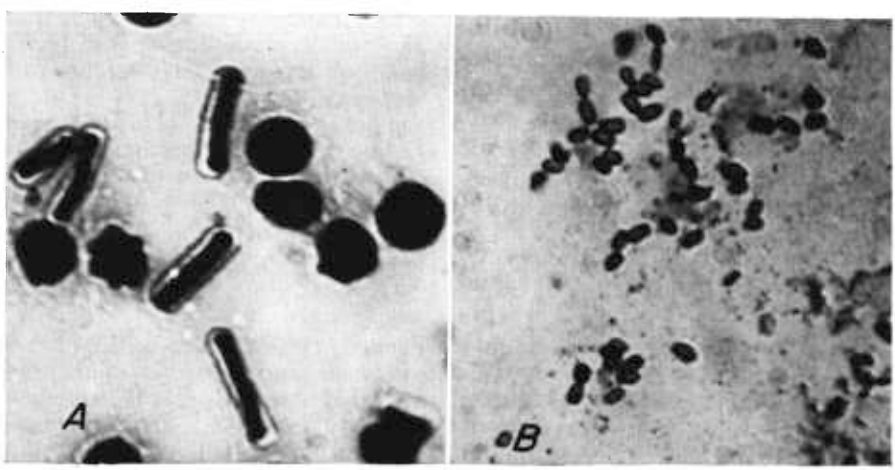
[1] This is a revision of former editions by W. S. Gochenour.

Cause of the Disease

The anthrax germ, *Bacillus anthracis*, is the specific cause of anthrax. In certain areas, especially those subject to periodic flooding, in low-lying marshy land, or in soils that are rich in decomposed vegetable or animal remains, the germ is indigenous to the soil and survives therein for long periods.

In their active (vegetative) state the anthrax organisms are microscopic in size and cylindrical or rodlike in form, with square ends (fig. 1, *A*). When the bacilli gain access to the animal body they multiply rapidly, invading the blood stream and producing a rapidly fatal blood infection, or septicemia.

When exposed to conditions unfavorable to their existence and growth, the anthrax bacilli form spores—that is, they change from an active to a dormant, or resting, state. Live, growing anthrax bacilli that pass from the bodies of sick animals onto the ground usually form spores. These spores, which develop within the body of the anthrax bacillus, are extremely small, oval-shaped objects similar to seeds, remarkable for their viability and resistance to heat, cold, chemical disinfectants, and prolonged drying (fig. 1, *B*). Numerous instances are on record to show that spores remain alive in the soil, in water, on hides, and in storage for many years. The bacilli themselves, however, show very little resistance to heat and drying.



A, 77955–B; B, 77956–B

FIGURE 1.—*A*, Photomicrograph of blood from a sheep that died of anthrax, showing rod-shaped anthrax bacilli in their active state. The halolike effect around each bacillus is the capsule. The rounded objects are red blood cells (X about 1,000); *B*, photomicrograph of an anthrax culture showing the resistant oval-shaped anthrax spores. Note the resemblance to minute seeds (X about 1,000).

Geographical Distribution and Seasonal Occurrence

Anthrax is widely distributed, having appeared on every continent. Areas known as anthrax districts, where the soil is heavily contaminated and where there have been repeated outbreaks, exist in southern Europe, parts of Africa, Asia, Australia, and North and

South America. In such districts the disease constitutes a perennial problem, making its appearance at a fairly definite period known as anthrax season, usually in late summer or early fall. In the United States certain areas in southeastern South Dakota, northeastern Nebraska, a belt along the Texas Gulf coast, the delta region of the lower Mississippi including parts of Arkansas, Mississippi, and Louisiana, and sections in the San Joaquin and Sacramento valleys of California are recognized anthrax districts. In such areas the disease can be kept in check by appropriate preventive measures. Isolated cases or outbreaks, however, occur at other seasons of the year in many other sections of the United States.

Most outbreaks in livestock take place when animals are on pasture and frequently follow hot, dry summers, when growth of herbage is scant and the animals must graze close to the soil. During these dry seasons, swamps, ponds, marshes, and bottom lands dry out and become available for pasture. In close grazing, roots in many instances with infected soil clinging to them, are consumed by animals along with vegetation. Periods of rainy weather favor the occurrence of the disease. Heavy losses from anthrax often follow in the wake of floods and periodic inundations of low-lying land.

During some years losses from the disease may be comparatively light, and the cases scattered. In other years the disease assumes a virulent form, appearing simultaneously at a number of places, spreading rapidly to new areas, causing heavy losses of livestock, and assuming the proportions of a major outbreak.

How Anthrax Is Spread

The spread of anthrax may be brought about by contamination of the soil, drinking water, and pasture and hay plants with the excreta and discharges of diseased animals. Dogs, coyotes, and other carnivora, as well as the carrion-eating animals and birds, particularly buzzards, are potential spreaders of anthrax from one area to another. Flying insects and blood-sucking flies must be considered as potential carriers. Animals sick of anthrax become easy prey to myriads of flies and other insects. Virulent anthrax organisms have frequently been found in or on the bodies of flies collected while feeding on carcasses of animals dead from anthrax (fig. 2).

Streams contaminated with anthrax soil may carry the infection to distant points, especially during floods. Anthrax may spread from one country to another through the interchange of infected objects closely associated with animal life, including hair, hides, wool, bonemeal, fertilizer, and forage.

The United States Department of Agriculture endeavors to prevent the further introduction of this disease into the United States through the administration of regulations by the Animal Inspection and Quarantine Branch governing the importation of bonemeal for use in either fertilizer or feed.

Some of the States also have laws regulating operation of rendering plants and feed-mixing plants and requiring that all bonemeal and other animal products used in fertilizer or feeds be heat-treated at sufficiently high temperatures to destroy anthrax spores.

70727-B

FIGURE 2.—Cow dead of anthrax.

Animals Susceptible and Mode of Infection

Practically all animals are susceptible to anthrax in some degree, but cattle, horses, sheep, and goats, are most commonly affected. Man and swine possess a greater natural resistance to the disease. Under certain conditions, dogs, cats, and wild animals of prey as well as birds, frogs, and toads may become infected. Mice, guinea pigs, and rabbits, which are commonly used in the laboratory diagnosis of anthrax, are very susceptible but rats show considerable resistance.

Infection in cattle, horses, mules, sheep, and goats usually occurs by way of the digestive tract, as a result of grazing on infected pasture land, or of eating contaminated fodder or artificial feedstuffs, such as bonemeal, blood meal, oil cake, and tankage; or of drinking from contaminated pools. Infection may also occur by way of the skin. Anthrax spores from the soil lodge in wounds and abrasions, or enter through punctures made by biting insects that had previously fed on a diseased animal. Infection may also take place through the respiratory tract, the inhaled spores setting up a rapidly fatal form of pneumonia. This form of anthrax is recognized in man more often than in the lower animals.

Swine, dogs, cats, minks, and wild animals held in captivity usually acquire the infection from consumption of infected meat. Swine may acquire the disease by following cattle in areas where the disease exists, from pasturing on infected soil, and from the ingestion of contaminated feed. Widespread outbreaks in swine herds in the middle western section of the United States in 1952 were traced to mixed feeds containing imported bonemeal contaminated with anthrax spores. Spontaneous outbreaks in antelopes, buffaloes, camels, deer, elephants, elks, ostriches, reindeer, and wolves have been reported from different parts of the world.

Forms and Symptoms of Anthrax

Anthrax may occur in a peracute, acute, subacute, or chronic form; there is also a cutaneous form.

The peracute form is characterized by sudden death as from a stroke. The onset is so sudden and the course so rapid that few if any clinical symptoms are observed. The usual picture associated with this form is one of cerebral apoplexy—sudden staggering, collapse, a few convulsive movements, and death. A blood-stained discharge from the mouth, nose, and anus may also be observed. Victims are frequently found dead without having shown any previous evidence of illness. This form is most common in cattle and sheep, occurring at the beginning of an outbreak. The sudden death of cattle, sheep, and horses in known anthrax territory should always be regarded with suspicion.

The acute form usually ends in death in a day or two; the subacute form may lead to death in 3 to 5 days or longer or to complete recovery after several days.

Chronic anthrax occurs occasionally in cattle, horses, and dogs, with local lesions confined to the tongue and throat, but is observed mostly in swine.

A cutaneous form of anthrax characterized by swellings in various parts of the body may occur in cattle and horses when infection has entered through the skin. It sometimes follows vaccination or the bites of infected flies (fig. 3).

The symptoms of anthrax vary according to the species of animal affected and the acuteness of the attack. The average period of incubation (the period of time elapsing between exposure to infection and the appearance of the first symptoms) under natural conditions is not definitely known but it is believed to vary from 24 hours to 5 days or much longer.

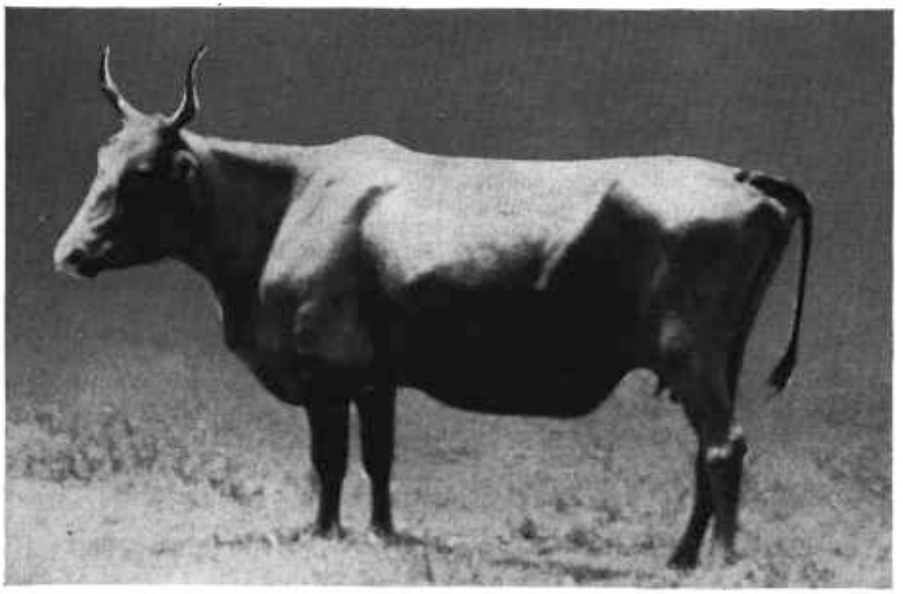


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FIGURE 3.—A subacute case of bovine cutaneous anthrax. Note edematous swelling in the shoulder, brisket, and ventral portion of abdomen. (Courtesy of Dr. I. P. Coulter, Florida Livestock Sanitary Board.)

In the acute and subacute forms of the disease in cattle, which is the species of animal most often affected in the United States, there is first excitement followed by depression, stupor, spasms, evidence of respiratory or cardiac distress, staggering, and death. During the course of the disease the body temperature may reach 107° F., pregnant animals may abort, rumination ceases, and in milking cows the milk secretion is materially lessened. Bloody discharges from the natural body openings are common and soft swellings that pit on pressure may develop in different parts of the body. Just before death the temperature falls below normal, respiration becomes extremely labored, and the mucous membranes become dark blue in color.

In horses and mules the first indication of anthrax infection may be severe colicky symptoms accompanied by high temperature, chills, loss of appetite, extreme depression, muscular weakness, and the passage of bloodstained feces. Hot, painful, and rapidly progressing swellings frequently develop over the body especially about the neck, lower abdomen, and external genitalia. Anthrax in the horse may be confused with colic, septicemia, acute swamp fever, purpura hemorrhagica, and other conditions.

In sheep and goats, anthrax occurs most often in the peracute form. The symptoms are unsteady gait, trembling, restlessness, difficult breathing, blood discharged from the natural body openings, and convulsions preceding death. Anthrax in sheep may be mistaken for blackleg and malignant edema.

In swine, the outstanding symptoms of anthrax are marked swelling of the throat and tongue with frequently a blood-stained frothy discharge from the mouth. When infection follows feeding on anthrax-infected material, some of the animals may die without having shown previous signs of illness. Others may show symptoms such as a rise in body temperature, loss of appetite, depression, chills, and muscular tremblings with rapidly progressing swellings about the throat, which may cause death by suffocation. A relatively large percentage of the group may become visibly sick for a few days, with or without moderate swellings about the throat, and then develop the disease in a chronic form, or make a gradual recovery. However, on post mortem examination weeks later, some of these animals may show evidence of anthrax infection in the cervical lymph glands and tonsils.

Anthrax in dogs, cats, and other carnivora usually is a result of eating meat from anthrax-infected carcasses. Dogs are affected chiefly with pharyngeal anthrax or anthrax of the tongue in which swelling may occur about the head and the throat. Anthrax of the intestines also occurs in dogs, manifested as a severe gastroenteritis. While all dogs are more or less resistant to the disease, older dogs seem to be the least susceptible.

Under natural conditions poultry are highly resistant to anthrax, and other types of birds, reptiles, and fish are not susceptible.

Post Mortem Findings

Post mortem examination of animals dead of anthrax usually reveals anatomical changes associated with an acute blood infection. In the very rapidly fatal cases the alterations in the blood and tissues are usually slight, but in acute and subacute cases of longer standing the anatomical changes are marked.

Carcasses of animals dead of anthrax decompose rapidly and soon become greatly bloated. The nat-

ural post mortem stiffening of the muscles is incomplete. Dark blood escapes as a rule from the natural openings, and the visible mucous membranes are dark blue in color and frequently show hemorrhages. The blood is considerably darker than normal, does not clot readily, and is spoken of as being tarry. Hemorrhages beneath the skin are common. Clear or somewhat blood-tinged gelatinous exudates are found between the muscles and beneath the skin, especially in the areas where the swellings were seen before death.

With rare exceptions the spleen shows characteristic changes, which are of assistance in making a diagnosis of anthrax. This organ is greatly enlarged, and the splenic pulp is dark red to blackish in color and soft or even semifluid in consistency; it may have the appearance of blackberry jam. The liver, kidneys, and lymph glands are usually congested and enlarged and show areas of hemorrhage.

In hogs the outstanding anatomical changes are confined principally to the region of the throat, where there is a marked gelatinous and hemorrhagic condition of the connective tissues and lymphatic glands. The tonsils are enlarged and frequently are covered with a dark, discolored, false membrane. Swelling of the structures forming the glottis is also observed. Although the spleen in affected hogs is frequently normal in size and color, enlarged, dark, and soft spleens may be found when the disease has become generalized.

Local lesions of long standing are sometimes found in the throat region of slaughtered hogs that had shown no visible signs of anthrax and were apparently healthy prior to slaughter. In these cases the disease is confined to the pharynx and adjacent tissues, including the lymphatic glands of that region. Localization of anthrax in the intestinal lymph glands has also been observed. In this chronic localized type the lymph glands of the head may be either slightly or greatly enlarged, hard, and fibrous. The cut surface presents a mottled appearance, produced by brick-red areas, patches, or streaks having a dull-gray, parboiled appearance. One or both tonsils may show areas of inflammation and degeneration ranging in size from that of a pinhead to that of a silver dollar.

Anthrax in Man

Although anthrax is primarily a disease of animals, it is transmissible to man, either directly by contact with infected animals or their carcasses, as in skinning, butchering, or making post mortem examination (agricultural anthrax), or indirectly by manipulation of infected animal material, such as hides, wool, and hair (industrial anthrax).

In man the disease may occur as an infection of the skin, the lungs, or the intestines. The external carbuncle form affecting the skin, is most prevalent. The lesion first appears usually on exposed regions, such as the hands, arms, neck, and face, as a small pimple, which rapidly develops into a large vesicle with a black center (fig. 4). If the local skin lesion is not treated promptly, it may result in a generalized blood infection. The form known as woolsorter's disease affects principally the lungs and is due to inhalation of spores during the processing of hair and wool.

83445–B

FIGURE 4.—Anthrax lesion on the finger of a man 5 days after he had skinned an anthrax carcass and performed an autopsy on it. Typical black center is surrounded by edematous tissue, beefy-red in color. (Courtesy of The Wisconsin Medical Journal, February 1941: "Anthrax in Wisconsin," by Drs. T. E. Wyatt and S. Epstein, Marshfield Clinic.)

This form of the disease is usually fatal. In countries where the flesh of animals dead of disease is eaten, an intestinal form of anthrax sometimes follows the consumption of contaminated meat.

Anthrax is occasionally transmitted to man by spore-infected shaving brushes, by apparel such as furs and leather goods, or by other animal byproducts not properly sterilized. The regulations of the U. S. Public Health Service now require that all interstate shipments and importations of hair and bristles intended for use in the manufacture of lather brushes be sterilized.

Prompt diagnosis and early treatment are of utmost importance in combating the disease. Excellent results are obtained with anti-anthrax serum, arsenicals, and antibiotics, such as pencillin, aureomycin, chloromycetin, and terramycin, the treatment of choice being penicillin or terramycin.

What To Do in Suspected Cases

When an animal dies within an anthrax district or on or near premises where the disease has appeared previously, it is very important to know definitely whether the death was due to anthrax. Lack of such information has often been responsible for heavy losses of livestock and at times the loss of human lives.

If anthrax is suspected, the stockman should consult a veterinarian at once. He should not open the carcass to attempt a diagnosis himself because of the serious danger of infection, and of the increased danger of spreading the disease. The veterinarian is prepared to take all necessary precautions against infecting himself and the premises.

For the same reasons the carcasses of such animals should never be skinned to save the hide, nor should they be fed to dogs, cats, or chickens, nor removed to a rendering plant for disposal. If local veterinary service is not available, consult the State livestock sanitary officials.

Diagnosis and Laboratory Examination

Especially in noninfected anthrax territory, the diagnosis of anthrax from clinical symptoms and anatomical findings may be difficult because of the similarity of these symptoms to other disease conditions. A definite diagnosis of anthrax in such instances can be made only by laboratory examination.

In peracute anthrax, death is so sudden and the clinical symptoms are so meager that a definite diag-

nosis is impossible without the aid of laboratory examination. Cerebral hemorrhage, sunstroke, lead poisoning, or some fatal digestive disturbance may be confused with peracute anthrax, especially in the so-called anthrax districts.

Any previous occurrence of anthrax on the premises is sufficient reason for considering anthrax as a possible cause of deaths among livestock that cannot be clearly attributed to other causes. In most instances a tentative diagnosis of anthrax can be substantiated by laboratory examination. Specimens for examination should be collected by a qualified veterinarian. In case professional services are not available the operator must take the greatest care to avoid infecting himself. Heavy rubber gloves should be worn to prevent the infectious material from coming in contact with the hands.

Specimens for laboratory examination should be obtained from the dead animal soon after death and before putrefaction sets in. The most satisfactory material for examination when shipped great distances consists of blood which has been collected on swabs, blotting paper, or glass slides, and which has been allowed to dry and, therefore, sporulate. For this purpose blood may be collected from the jugular vein by means of a sterile needle, or from the superficial blood vessels of the ear, legs, or tail. Place the specimens in a sealed clean container, label it "suspected anthrax," and enclose it in an unbreakable receptacle, such as a metal mailing tube, for shipment to the laboratory.

Ears, spleen tissue, and blood samples when collected from animals a short time after death and brought to the laboratory within a few hours make very satisfactory material for examination. When anthrax in swine is suspected, specimens of the lymph glands of the throat packed in borax should be submitted for examination, as anthrax organisms are rarely found in the blood stream of this species.

A conclusive laboratory diagnosis of anthrax is based on positive microscopic and cultural findings supplemented by animal inoculation tests.

Control Measures

What To Do in Actual Outbreaks

The effective control of anthrax requires the combined action of livestock sanitary officials, local veterinarians, and owners of livestock. When the disease appears or is suspected in a herd, it is advisable to obtain the assistance of a veterinarian or State livestock official as soon as possible.

When a diagnosis of anthrax has been made, the following measures are the most effective means of control:

(1) The prompt disposal either by complete burning or by deep burial of animals dead of the disease, together with all the manure, bedding, blood-stained soil, and other contaminated material.

(2) A careful examination of the herd for animals showing early symptoms of the disease, the prompt isolation of sick animals, and immediate treatment with large doses of antianthrax serum, penicillin, or terramycin.

(3) Vaccination of the apparently well animals in the herd as soon as possible.

(4) Immediate change of pastures if practicable. This precaution in itself has in many instances helped to reduce losses.

(5) A strict quarantine of premises rigidly enforced.

(6) Use of effective fly repellents on dead animals, sick animals, and apparently well animals in an infected herd to prevent spread of the disease by flies.

(7) The source of the infection should be determined if possible and efforts made to prevent further exposure.

Outbreaks in Stabled Animals

When anthrax occurs in stabled animals, prompt and thorough disinfection of the quarters should follow the removal of the dead animals. Every precaution should be taken to prevent spread of the infection through contaminated excreta.

There is always a possibility that rats or mice may transfer contamination to the hayloft or feed storeroom. Therefore special effort should be made in anthrax districts to get rid of these pests.

Manure from a stable where deaths from anthrax have occurred should be burned or deeply buried or, if this is impracticable, disinfected with very liberal applications of a 5-percent solution of lye. However, it is questionable whether applications of lye solution will disinfect completely large quantities of manure. It is impossible, therefore, to make general recommendations on the disposal or disinfection of manure that would be efficient and practicable under all conditions. Methods of procedure, therefore, should be left to the judgment of a veterinarian.

Outbreaks in a Dairy Herd

When an outbreak of anthrax occurs in a dairy herd, the dairy should be placed under strict quarantine, and all milk should be withheld from distribution until the public health officials and State livestock sanitary officials issue a clean bill of health. Precautions should be taken to prevent the contamination of milking cans, mechanical milkers, buckets, and other dairy equipment by contact with diseased animals and their excreta. Although there appears to be little likelihood of direct transmission of anthrax through the milk of infected cows, a few instances on record indicate that anthrax bacilli may be excreted in the milk.

The length of time a dairy should be quarantined following an outbreak of anthrax depends principally on the type of outbreak. The quarantine period varies in different States. Milk from infected cows, or milk believed to be contaminated with *B. anthracis*, should be destroyed by incineration, or be buried after boiling or treatment with 5-percent lye or 10-percent formalin to destroy the organism. The disposition of milk from healthy cows in an exposed or quarantined herd is a problem that must be decided by the health officials concerned, and depends to a great extent on the circumstances.

The U. S. Public Health Service in February 1953 furnished all State and Territory milk control authorities with specific recommendations in relation to anthrax in dairy herds. These recommendations were prepared by the U. S. Public Health Service with the assistance of the U. S. Department of Agriculture, the Federal Food and Drug Administration, and the Federal Civil Defense Administration, and were endorsed by cooperating agencies.

Disposal of Carcasses

In the control of anthrax, prompt and effective disposal of carcasses is of the greatest importance. This can be accomplished either by complete cremation or by deep burial under a layer of quicklime covered with at least 6 feet of earth. Carcasses should not be buried in low swampy land or adjacent to streams where overflow might inundate the grave, or on a hillside where there is a possibility of subsurface drainage reaching the surface at lower places nearby. The area above and around the grave should be saturated with oil and burned over.

In disposing of a dead animal, the following method is recom-

mended: Immediately after finding the animal, cover it with kerosene or crude oil to keep flies, dogs, buzzards, crows, and vermin away from it. If conditions permit, cremate or bury the carcass where it is found. If moving to a more suitable site is necessary, take the greatest care to prevent any discharges or hair from contaminating the soil over which the carcass is moved. Never permit a carcass to be dragged. A stoneboat or sled may be used as a means of conveyance. Thoroughly disinfect or burn any equipment used in moving the carcass. Avoid actual contact with the germ-laden body, by using ropes and poles, which may then be burned. If possible have the disposal of anthrax-infected carcasses conducted under the supervision of a veterinarian.

The cremation of the carcass of a sheep or hog is not difficult, but the complete destruction of that of a horse or cow is more of a problem. There are several methods that give satisfactory results in the cremation of large carcasses. One of these is to dig two trenches approximately 2 feet wide and 18 inches deep, crossing each other at right angles, over which a grating of green posts is laid, followed by several layers of dry rails or split logs. After the carcass is placed on this pyre, straw and either kerosene or oil are used to start a good fire. Additional fuel is added as needed. A covering of sheet iron or green logs tends to conserve the heat and hasten the destruction of the carcass.

Another method requires no trenches. Oil is applied freely to the carcass, which is then covered with a liberal quantity of straw, and this in turn is covered with a thick layer of heavy, moderately dry manure. Burning the straw generates sufficient heat to start the manure burning, which continues slowly until the carcass is reduced to ashes. There should be plenty of oil, straw, and manure, and the carcass should be fully covered. This method (fig. 5) is slower than the one which involves the use of a rail pyre.

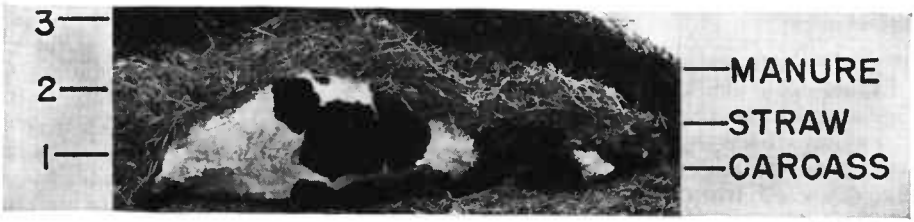

FIGURE 5.—A carcass which is to be disposed of by cremation. The steps are as follows:
1. Saturate carcass with kerosene, crankcase oil, or any inflammable oil.
2. Cover carcass with a hayrack full of straw.
3. Place two loads of heavy manure on top of the straw and set it afire.
4. Add manure daily or as often as necessary to keep carcass covered until it is burned to a white ash.

Disinfection and Other Control Measures

Of the disinfectants, lye is one of the most effective. For disinfection of premises against anthrax, a 5-percent solution is recommended. To prepare such a solution 2½ pounds of commercial lye containing 94 percent of sodium hydroxide is dissolved in 5½ gallons of water. Where a whitewash is not objectionable, water-slaked (not air-slaked) lime may be added to the lye solution in the proportion of 2½ pounds of lime to each 5½ gallons of lye solution for the purpose of preventing the transforma-

tion of the active principle, sodium hydroxide, into sodium carbonate, which is considerably less effective as a germicide. Use the lye or lye-and-lime solution as soon as it is prepared. Thoroughly soak the premises with the disinfectant, and allow it to remain on for at least a day. Then thoroughly wash it off with clean water before the livestock are returned.

When anthrax is prevalent, keep the dogs tied up and discourage in every possible way stray dogs from coming on the premises. Such animals may spread the infection.

For the same reason action should be taken to protect livestock from the dangers of buzzard and crow roosts. Protection from flies and biting insects so far as practicable is advisable also.

Thorough inspection of premises where outbreaks of anthrax have occurred may disclose pools or marshlands that are potential sources of infection. Such places, as well as parts of pasture lands known to be heavily infected, should be fenced off so far as is practicable.

Although the disease can be introduced through means beyond man's control, every effort should be made to guard against possible introduction by needless or faulty vaccination with living-spore anthrax vaccines, roaming dogs, especially when anthrax is prevalent in the vicinity, and the use of hay, straw, or other forage originating on premises where anthrax infection is known to exist.

Vaccination

Prophylactic vaccination of livestock against anthrax dates from Pasteur's epoch-making demonstration in 1881 in France in which he proved that sheep could be successfully immunized against artificial exposure to the disease.

In known anthrax districts the disease can be largely controlled by annual vaccination of livestock. In areas where the disease is apt to occur perennially best results can be expected from vaccinating animals 4 to 6 weeks before turning them into pasture.

While vaccination of exposed animals will reduce losses and assist in controlling the disease, results may not be as satisfactory as when animals are vaccinated prior to the outbreak. Vaccination may be followed by a period of lowered resistance preceding the establishment of immunity, during which the susceptibility to anthrax may be increased. Vaccination is not 100 percent effective, however, regardless of the method or the vaccine used. It is not uncommon for anthrax to develop in an occasional animal that has been vaccinated with an anthrax biologic that apparently affords protection to the rest of the herd. An occasional loss from anthrax in a vaccinated herd does not constitute grounds for questioning the value of the biologic, nor does it justify hasty revaccination of the herd.

The selection of the anthrax vaccine should be left to the local veterinarian or State livestock sanitary officials who, because of their experience and knowledge of the local conditions, are in a position to know which products are best suited to the needs of the herd.

Agents Used in Vaccinating Livestock

The immunizing agents available for vaccination of animals against anthrax are of two types: Sterile products (antianthrax serum and anthrax bacterin), and live-spore vaccines consisting of suspensions of living anthrax spores of different degrees of strength in a

solution of normal saline and glycerine.

Antianthrax serum is made from the fluid part of the blood of horses, mules, or cattle that have undergone a process during which the serum became heavily charged with anthrax-immune bodies. When injected into animals antianthrax serum produces resistance in direct proportion to the quantity of serum given. It is of value both as a preventive and as a therapeutic agent. The immunity which it confers, however, is of relatively short duration. As a preventive, therefore, antianthrax serum should be used when immediate protection is the principal objective, even though the immunity is only temporary. When serum alone has been given to the apparently healthy animals in an infected herd, it should be followed 10 days later by vaccination with an agent that will produce a more enduring immunity.

Anthrax bacterin, which consists of a heavy suspension of formalin-killed anthrax organisms, differs from antianthrax serum in that it stimulates the treated animal to produce immune bodies, whereas the serum treatment is merely a mechanical transference of immune bodies to the treated animals. The protection afforded by bacterin is not established so early as that with serum, but it is of longer duration. Bacterin, being sterile, is in itself incapable of producing disease in the treated animal and is, therefore, safer than the living-spore anthrax vaccines.

The anthrax-spore vaccines, on the other hand, produce a higher degree of immunity than do bacterins and are widely used in all parts of the world for the immunization of livestock against anthrax. These products may be used alone or in combination with antianthrax serum. The spores in these vaccines are so weakened that under ordinary conditions they will not produce the disease if the vaccines are administered according to directions. In accordance with the degree of virulence they possess, they are classified as Nos. 1, 2, 3, and 4 spore vaccines.

A new type of spore vaccine of low virulence prepared from an uncapsulated variant strain of *B. anthracis* has been developed in recent years by Stern at the Onderstepoort Veterinary Research Laboratory, Pretoria, Union of South Africa. It has been used with excellent results in South Africa, England, India, and many other countries. A spore vaccine of this type is now being produced and distributed in the United States. The No. 1 spore vaccine, of low virulence, is used for the preliminary injection in the double or triple injection method of vaccination. The No. 2 spore vaccine is used in areas where an ordinary type of infection exists, and Nos. 3 and 4 are used in areas where there is a virulent type of infection.

Satisfactory results have been obtained with spore vaccines given subcutaneously by the single-, double-, or triple-injection method. However, in known anthrax areas, exceptionally good results are obtained by single injections given intradermally—that is, the vaccine is injected into the skin and not under the skin. The spore vaccine is of selected virulence and produces a rapid, solid, durable immunity with little or no reaction. The intradermal method is especially useful for immunizing exposed animals in an infected herd.

Since swine are generally considered highly resistant to anthrax, prophylactic vaccination even in known infected areas is not carried out on a wide scale. However, in exposed herds reports indicate that the administration of antianthrax serum, bacterins, and spore vaccines, either singly or in combination, give good results.

The simultaneous administration of antianthrax serum and sub-

cutaneous spore vaccine (Nos. 2, 3, or 4) is likewise an effective method of immunization and is the method preferred by many veterinarians for vaccinating exposed animals during an actual outbreak.

The use of spore vaccines requires considerable discretion, and immunization should be carried out in accordance with recommendations of the livestock sanitary officials.

Ordinarily spore vaccines of low virulence such as Nos. 1 or 2, when properly administered, should cause little or no reaction in most animals. However, in highly susceptible animals, severe reactions and an occasional death may occur following vaccination, especially with the more virulent Nos. 3 and 4 spore vaccines. Since sheep, goats, mules, and horses are very susceptible to anthrax, spore vaccines should be used with discretion on these animals. Certain other factors, such as the site of inoculation, fatigue, general condition of the animal, temperature, and humidity may to some extent influence the type of reaction following vaccination. Spore vaccines should never be used on animals showing symptoms of anthrax.

In the administration and handling of spore vaccines the recommendations of the manufacturer should be closely followed. It is ordinarily inadvisable to use anthrax spore vaccines on premises where the disease has not existed unless danger from exposure is imminent. The operator must take care to prevent contamination of the surroundings and of himself.

In anthrax areas vaccination with the proper type of immunizing agent usually affords protection for a season, but should be repeated annually. In some endemic areas that have a long anthrax season, a booster dose is administered 4 to 6 months after the first vaccination.

Treatment

In infected herds animals showing temperature and other early symptoms of anthrax may recover under prompt treatment, but in most instances treatment of animals showing advanced symptoms is of little value.

For many years antianthrax serum was most commonly used for the treatment of anthrax in animals. Best results were obtained by intravenous injections of the serum in large doses of 50 to 100 cc. or more during the early stages of the disease. In recent years, however, the trend appears to be toward the use of antibiotics such as penicillin and terramycin. Although the Department of Agriculture has conducted no experiments to determine the merits of these antibiotics in the treatment of anthrax, clinical reports from veterinarians in the field indicate that they may have considerable therapeutic value if properly administered during the early stages of the disease. Treatment of affected animals should be under the direct supervision of a veterinarian.

Individual Responsibility

Since anthrax is a serious disease from both an economic and public health standpoint, the problem of control is a common cause to which every livestock owner should contribute. All persons concerned should cooperate to the fullest extent with the livestock sanitary and public health officials in the known measures for its suppression.

U. S. GOVERNMENT PRINTING OFFICE: 1955